DISPOSAL OF MINE WASTES BY BACKFILL OF EXISTING MINE EXCAVATIONS AT AN ABANDONED LEAD MINE IN MONTANA[1]

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Abstract. The abandoned Cumberland Lead Mine Site near the historic ghost town of Castle was reclaimed by the Montana Mine Waste Cleanup Bureau in 2001. Reclamation of the site included the excavation and relocation of approximately 20,000 cubic yards of smelter slag and waste rock into an existing excavated pit. Prior to waste placement, a vertical shaft located in the pit was backfilled and the pit bottom was sealed with a 12 inch layer of native clay. Mine waste was placed into the pit repository in defined layers to better isolate the smelter slag within the backfilled waste. Another 5000 cubic yards of less contaminated mine waste were placed in a 100 foot long, 15 foot deep exploration trench. Both the pit and trench were capped with a multi-layer cap consisting of a geosynthetic liner overlain by a geocomposite drainage fabric covered by 18 inches of cover soil.

Additional Key Words: pit, repository, trench, cap

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Introduction

Disposal of smelter slag and other mine wastes in the pit excavation and a exploration trench at the Cumberland mine not only resulted in a significant cost savings when compared to the more conventional mine reclamation techniques, but also allowed the mine reclamation to be completed in an expedited manner**.** Five years of post reclamation site monitoring has shown this approach was reasonable and successful.

Site Description and History

The Cumberland Mine site is an abandoned mine and smelter site located near the ghost town of Castle in Meagher County, Montana. Site features includes two shafts, an adit, an excavated pit, exploration trenches, waste rock dumps, and a smelter slag dump (Figure 1).

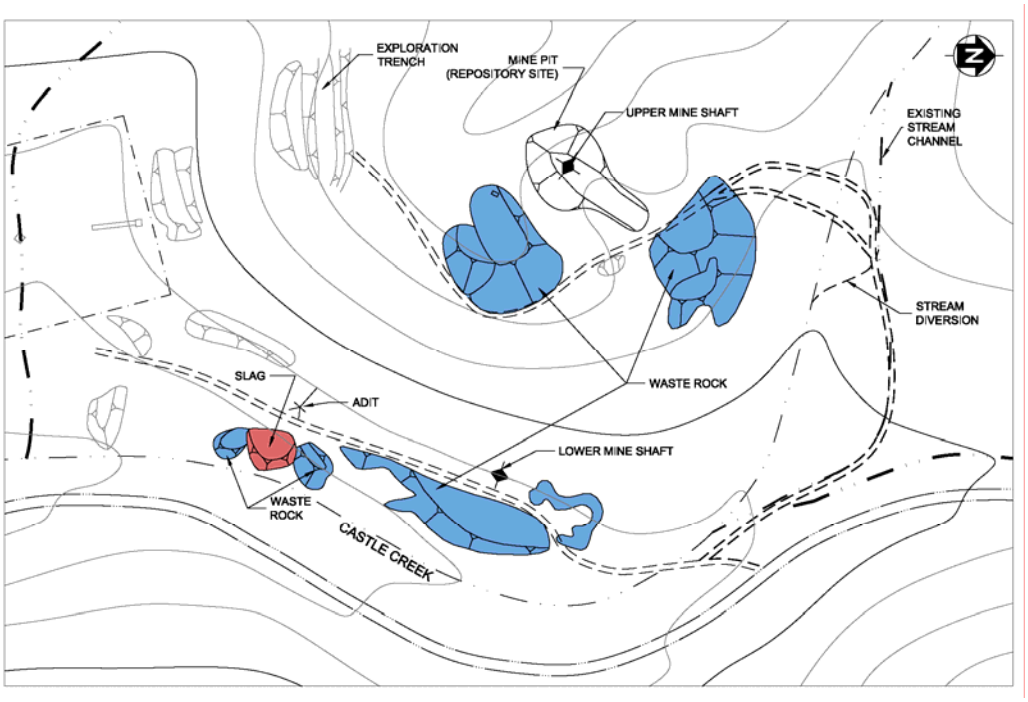

Figure 1. Cumberland Mine Vicinity Map

The mine site occupies a block of four patented claims including the Cumberland Lode, the Cumberland No. 2 Lode, the Stonewall Jackson Lode, and the Monument Lode in the Castle Mountains Mining District. Castle Creek, a small ephemeral stream that is a tributary of the Musselshell River, runs through the lower part of the mine site. Elevation at the mine site ranges from 6,200 feet along Castle Creek to over 6,500 feet at the top of the mine pit highwall.

Lead ore was first discovered at the Cumberland lode site in 1884. The ore occurs as a replacement deposit in the Madison limestone. By 1891, the Cumberland Mine was the largest producer of lead ore in the State of Montana (Renewable Technologies, Inc. 1997). Mining and smelting occurred at the site primarily during the early 1890s. Some

ore was shipped from the historic dumps in the 1920s to the East Helena lead smelter. The underground workings were sporadically developed in the 1940s, 1950s, and 1960s.

Several development shafts and extensive underground workings are present at the site. The discovery (upper) shaft is located on the Cumberland Lode on an outcrop of the vein and was reportedly sunk to a depth of 700 feet (Figure 2). The main (lower) shaft is located on the Stonewall Jackson Lode and was sunk to a depth of 500 feet. An adit is also located on the Stonewall Jackson Lode just upslope from the smelter slag dump. Groundwater was apparently encountered in both shafts. During mining groundwater had to be pumped to the surface for discharge.

Figure 2. Upper Shaft Headframe. August 2000.

Surface mining of the discovery outcrop apparently occurred sometime after 1965. This mining resulted in a large pit centered on the Cumberland Lode shaft. Additional exploration work during this same period resulted in several large trenches around the mine site.

A smelter was constructed on the Stonewall Jackson Lode in 1888 to process the oxidized ore produced at the mine. The smelter operated from 1889 to 1893 until the ore changed from oxide to sulfide. Because the smelter could not efficiently treat the ore due to increasing zinc content, the smelter was closed and further smelting was done in East Helena.

A large pile of smelter slag remained at the site after it was abandoned along with several waste rock dumps and abandoned ore piles (Figure 3). Several structures were

present on the site including a wooden headframe located on the upper shaft, a mine office including the remains of the assay laboratory, and the remains of smelter furnace (Figure 2). The lower shaft appeared either to have collapsed or been backfilled with old machinery and other metal debris. An adit located just above the slag dump was backfilled in the 1950s after a hunter who had taken shelter in the adit during a storm died from exposure to "bad" gas within the adit (Rademacher, 2001).

Figure 3. Smelter Slag Dump. April 2000.

Site Investigation

A hazardous materials inventory was completed at the Cumberland Mine site in 1993 by the Montana Department of State Lands Abandoned Mine Reclamation Bureau (MDSL, 1995). The contaminants of concern at the Cumberland Mine site were primarily arsenic, lead, and manganese. The maximum measured arsenic concentration was 861 milligrams per kilogram (mg/kg). The maximum measured lead concentration was 52,500 mg/kg. The maximum measured manganese concentration was 4,704 mg/kg. Based on this inventory the mine was assigned an Abandoned and Inactive Mines Scoring System ranking of 43 out of 273 mines surveyed.

In 1998, a remedial investigation (RI) and engineering evaluation and cost analysis (EECA) were completed for the site (Maxim 1998). As part of the RI, additional sampling was completed. The maximum measured arsenic concentration was 2,000 parts per million (ppm) and the mean detected concentration was 942 ppm. The maximum measured lead concentration was 68,200 ppm and the mean detected concentration was 28,451 ppm. The maximum measured manganese concentration was 10,600 ppm and the mean detected was 2,767 ppm. Reclamation alternatives evaluated for the site included

consolidating, capping and revegetating selected mine waste in place and excavation and disposal of mine waste in a modified Resource Conservation and Recovery Act (RCRA) type repository located on an adjacent property parcel. The total present worth for the disposal of mine waste in a repository was estimated at $378,000.

Based on difficulties in obtaining access to the adjacent land parcel for use as a waste repository (Herbort, 1999), the State decided to evaluate additional reclamation alternative including excavation and disposal of mine waste within the Cumberland Mine pit. Tetra Tech EM Inc. (TtEMI) was retained to prepare an addendum to the RI/EECA. Based on a revised risk assessment, it was determined that excavation and disposal of the mine waste within the mine pit with an estimated total present worth of $366,000 was the most cost effective reclamation method that was protective of both human health and safety and the environment (TtEMI 1999).

Reclamation Design

In 2000 Tetra Tech EM Inc. was retained by the Montana Department of Environmental Quality Mine Waste Cleanup Bureau to prepare plans and specifications for reclamation of the Cumberland Mine.

The most important element of the proposed reclamation was the design of the proposed pit repository. The pit geometry was such as to rule out the use of a standard multi-layer geomembrane as a pit bottom liner. Instead, it was decided to provide a partial pit bottom liner consisting of a one foot thick layer of native clay. Prior to installation of the liner it would be necessary to remove the upper shaft headframe, backfill the shaft, remove loose rock from the pit bottom and sidewalls, and grade the pit bottom. It was also decided to construct the repository in layers to encapsulate the smelter slag in the middle of the mine waste (Figure 4). The design of the repository cap included a layer of geosynthetic clay liner directly on top of the graded waste, overlain by a layer of geocomposite drainage fabric covered by 18 inches of vegetated soil.

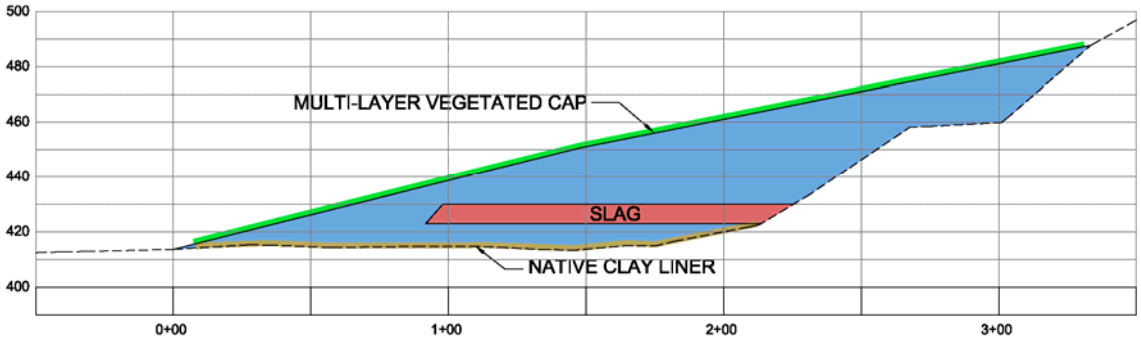

Figure 4. Cross Section through Pit Repository. Note encapsulation of smelter slag.

Other notable aspects of the proposed design included the backfill of a large exploration trench located south of the mine pit with lesser contaminated mine wastes, the restoration of a diverted stream channel, and the removal of metal debris from the lower (Stonewall Jackson Lode) shaft. Backfilling the exploration trench would not only isolate these wastes from the environment, but would also eliminate the safety hazards associated with this deep trench. While returning the stream channel back to a more natural alignment would not provide any additional protection from site contamination, it would substantially reduce problems with ongoing erosion and sediment transport into Castle Creek.

Special care was taken during selection of the revegetation seed mix to match the existing native plant community. Prior to finalizing the seed mix, the State project manager and design engineer walked the site in early summer to identify existing native plant species. When available, seeds of these species were included in the design seed mix.

Reclamation Construction

Due to the high elevation and north facing aspect of the mine site, it was decided to bid the project in the late summer of 2000 with the actual reclamation work scheduled to begin as soon as the snow melted in the spring of 2001. This allowed the prospective bidders to tour the site under roughly the same weather conditions they would encounter during construction.

The reclamation project was bid on August 17, 2000. Eight contractor bid the project with bids ranging from a low of $236,300.00 to a high of $453,767.50. The engineer's estimate was $309,900.00. The contract was awarded to the low bidder, Shumaker Trucking and Excavation, Inc. of Great Falls, Montana.

Work at the site commenced on June 25, 2001 and all work except for seeding was completed by August 15, 2001. Seeding of the site was completed in early October 2001. Approximately 20,000 cubic yards of slag and mine waste were successfully relocated to the mine pit repository. An additional 2,750 cubic yards of waste rock were placed in the exploration trench repository. Approximately 5,880 square yards of multi-layer goemembrane/soil cap were placed (Figure 5).

Figure 5. Laying Geosynthetic Clay Liner. September 2001.

During construction several issues arose that required changes to the contract. The most important changes were the need to backfill the lower shaft and provide additional backfill at the smelter adit. While removing the metal debris from this shaft, it was discovered that the adit was still open to a depth of approximately 200 feet. Approximately 60 cubic yards of backfill were required to seal this adit. While removing wood debris from the smelter adit, the existing backfill was determined only to be a few feet thick. This material was removed (Figure 6) and approximately 20 cubic yards of backfill were pushed back into this adit providing a substantially more effective seal.

Another significant change authorized during construction was the importation of several hundred yards of corral compost (aka, cow manure) from a local rancher's feed yard to augment poorer quality cover soil obtained from the site and used during reclamation to restore the former sites of the several waste rock dumps.

The final total cost of construction was $231,791.00 or $4,509.00 less than the price bid to complete the work. These savings were primarily associated with a reduction in the quantity of mine waste requiring relocation into the two on-site repositories.

Figure 6. Open Adit Exposed During Reclamation. September 2001.

Reclamation Monitoring

Site reclamation has been monitored by the state reclamation project manager and consulting design engineer on a yearly basis since completion of the work in 2001. While there are some areas of sparse vegetation within the reclaimed mine site due to the poor quality of the available cover soil, revegetation of the remainder of the site, especially the two repositories (Figure 7), has been exceptionally successful. Erosion of the reclaimed slopes is almost non existence.

Figure 7. Mine Pit Repository Cap Revegetation. June 2006.

Figure 8, a photograph of the smelter slag dump site taken this past summer , when compared to Figure 3, a photo of the smelter slag dump prior to reclamation; illustrates the successful reclamation of the site which once was the location of one of Montana's largest and most contaminated abandoned lead mines.

Figure 8. Reclaimed Slag Dump Site. August 2005.

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